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Original Article

The Effect of Groundwater Recharge and Abstraction on Groundwater Quality in Nairobi Aquifer System

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Abstract — *Using standard procedures, the study analysed water samples from 100 boreholes from Nairobi Aquifer System (NAS) for selected water quality parameters. Data from eleven monitoring boreholes from 2013-2019 was obtained from Water Resources Authority (WRA). The parameters were weighted, and their concentrations were used to develop Water Quality Indices (WQI). Abstraction data was obtained from WRA while recharge was estimated using SWAT Model. A Multiple regression model for WQI, abstraction and recharge variables was developed, and maps were created. Results showed the highest WQI of 0.4001 when recharge was 666,980.16* m^3*/year and abstraction 54,963,200* m^3*/year, and lowest WQI of 0.2861 when recharge stood at 346,483.20* m^3*/year and abstraction 41,586,600* m^3*/year. A strong correlation between abstraction, recharge, and WQI of* R^2 *0.86was observed. Areas with high recharge and low abstraction exhibited a low WQI of 0.2, while areas with high abstraction rates and low recharge showed relatively high WQI of 0.6. Therefore, it was concluded that water quality improved with decreased abstraction and recharge and deteriorated with increased abstraction and reduced recharge. It was recommended that abstraction be regulated in line with recharge rates and recharge be improved to maintain high water quality suitable for human consumption.*

Keywords — *Abstraction, Aquifer, Groundwater levels, Recharge and Water Quality Index.*

I. INTRODUCTION

Water quality is an important characteristic in determining the use into which the water will be put [10]. While groundwater generally has better quality than surface water [19], it contains ions whose concentrations should be kept within the set portability standards. This has influenced various studies on groundwater quality parameters such as TDS, $NO3^{-}$, $NO2^{-}$ Cl^{-}, $SO4^{2-}$ Ca^{2+} Mg^{2+} total hardness, Zn, Hg, C r, Cd, Ni, and Pb [17], [11], [14].

Recharge plays a role in groundwater quality whereby dilution of ionic concentrations through recharge increases three times as recharge increases and concentration of total dissolved solids decreases [24]. Parameters such as electrical conductivity [13] and Fluoride [8] decrease with an increase in recharge, improving groundwater quality. While recharge through runoff can cause contamination considering some parameters [4], the average concentration of water quality parameters reduces after the flood by dilution process [15]. Recharge is related to land use/ land cover changes, and the concentration of water quality parameters decreases with an increase in recharge [3], [9]. Groundwater quality shows an increasing trend of desalination of sulfate, iron, manganese content, organic and nitrogenous compounds [25].

Groundwater abstraction deteriorates groundwater quality by increasing parameters such as sulfate and chlorides due to mineral oxidation [7]. Long-term evolution of water quality comes up because of overdraft [22]. Over-exploitation leads to declining groundwater levels, which negatively impacts groundwater quality by increasing electrical conductivity [23]. Groundwater quality is influenced by geological characteristics, which show spatial-temporal variations in different parameters [18]. Industrialization and urbanization affect groundwater quality negatively [1]. Groundwater pollution in urban areas is high compared to other areas [12].

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Despite the findings of these researches, the extent to which recharge and abstraction affect the groundwater quality has not been focused on to inform water resources management and regulation in the relevant areas.

Nairobi Aquifer System, the focus of this study, is an aquifer underlying a city with rapid urbanization, industrialization, and a high population growth rate [6]. Parts of the study area, especially the city, do not have surface water supply sources as most rivers are highly polluted while the other parts are arid and semi-arid (ASAL). The area, therefore, depends on inter-basin water transfer from Murang'a in the Tana basin. To complement these water sources, several boreholes have been sunk within the NAS to provide additional water supply, which has led to a decline in groundwater levels [27]. Studies in NAS have ranked groundwater as good as per WQI [19], with most parameters being within the WHO standards except Nickel, lead, fluoride, and physical parameters such as PH and electrical conductivity in some areas [21], [29], and [17]. However, groundwater quality seems to deteriorate in some areas with time which makes it necessary to study the effect of abstraction and recharge on water quality. In 1999 abstraction rate was 15,116,742 m3/year with a population of about 2 million, while in 2019 abstraction rate was 72,379,531 m3/year with a population of about 6 million [28]. The rate of abstraction in Nairobi is increasing, fueled by population increase and industrialization as seen in the decline of groundwater levels [5] and reduced recharge rate due to increasing urbanization and the effect of climate change that is causing rainfall fluctuations.

II. MATERIALS AND METHODS

A. Study Area

NAS covers an area of approximately 6,500 km^2 and underlies much of the Nairobi metropolitan area. It is a complex, multilayered volcanic / volcano-classic aquifer system, recharged along the eastern edge of the Rift Valley with groundwater moving from the North-west towards the east. It is unconfined in the recharge zone, becoming confined with the eastward progression. The principal aquifer unit, the Upper Athi series, is entirely confined, with depths ranging from 120m to 300m below ground level. Aquifer characteristics range from 0.1 to 160 m^2/d for transmissivity from 0.01 to 1.3 m/d for hydraulic conductivity and from 1.2 x 10^{-4} to 4.2 x 10^{-1} for storage coefficient [16].

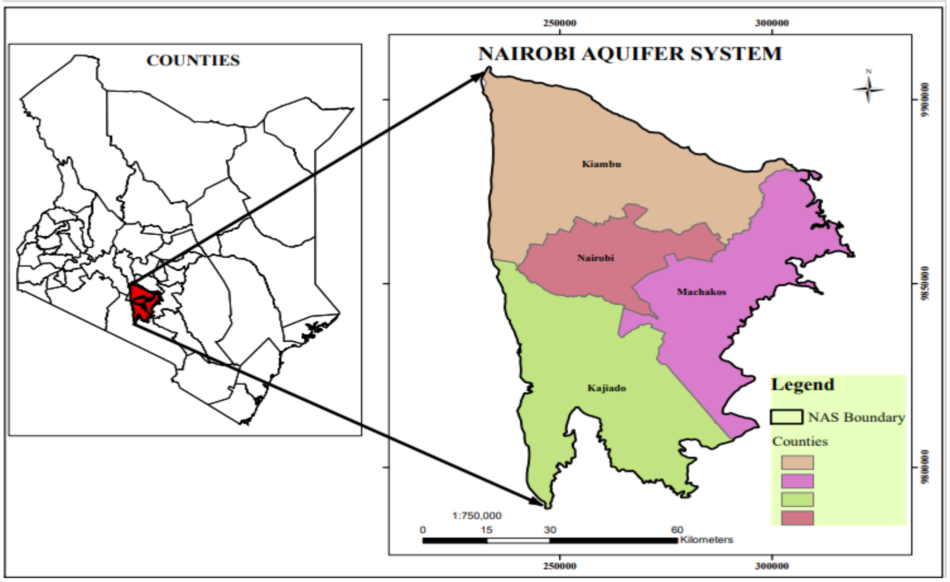

Fig. 1 Map of Nairobi Aquifer System (NAS)

NAS lies within the Athi basin, one of Kenya's five river basins (Water Resources Authority, 2018), and encompasses the counties of Nairobi, Kiambu, Kajiado, and Machakos (Fig. 1). It lies between latitudes 0°37' 58'' to 1°59' 23"S and longitudes 36°34' 27'' to 37°28' 17''E (Oiro, 2018) at an altitude of between 1400m to 2600 m above mean sea level (asl).

The area experiences a subtropical highland climate, with June and July as the coldest months. The area experiences a bimodal rainfall pattern, with the highest rainfall occurring in March-May, and November-December, respectively, with a mean annual rainfall of1050 mm. Average annual humidity ranges from 60% to 84%, with higher per cent occurring during rainy seasons. Flooding occurs during the wet season, particularly within residential areas and lowland plains [20].

B. Data Collection

Secondary groundwater quality data on total hardness, iron, calcium, magnesium, fluoride, PH, turbidity, TDS, electrical conductivity, nitrates, and sulfates for eleven monitoring boreholes from 2013-2019 was collected from the Water Resources Authority (WRA). The recharge for the aquifer was estimated based on climatic data such as rainfall, soil type, land use, land cover and terrain variables using the SWAT Model. In contrast, historical daily abstraction rate data from 2013-2019 was collected from WRA. The boreholes under study were located using a Geographical Positioning System (GPS) and mapped using QGIS. Water quality parameters such as total dissolved solids and PH were measured on-site using a portable water quality testing kit. Water samples for physical and chemical analysis were collected in clean 1-litre plastic bottles. The bottles were first washed with a detergent and rinsed with distilled water and finally with the sample water before taking a sample. All samples were then labelled with a code, source details, date, and sampling time and transported to the laboratory in cool boxes stacked with ice cubes for testing within 24 hours of sampling. NAS has a total of 9196 boreholes. The sample size was calculated using Equation 1.

$$n = \frac{N}{1 + N(e^2)} \qquad (1)$$

$$n = \frac{9196}{1 + 9196(0.1^2)}$$

n =98.9 hence approximated to 100 boreholes

Where; n = Sample size, e = error limit (0.1), N = the population size, (Israel, 2009)

C. Data Analysis

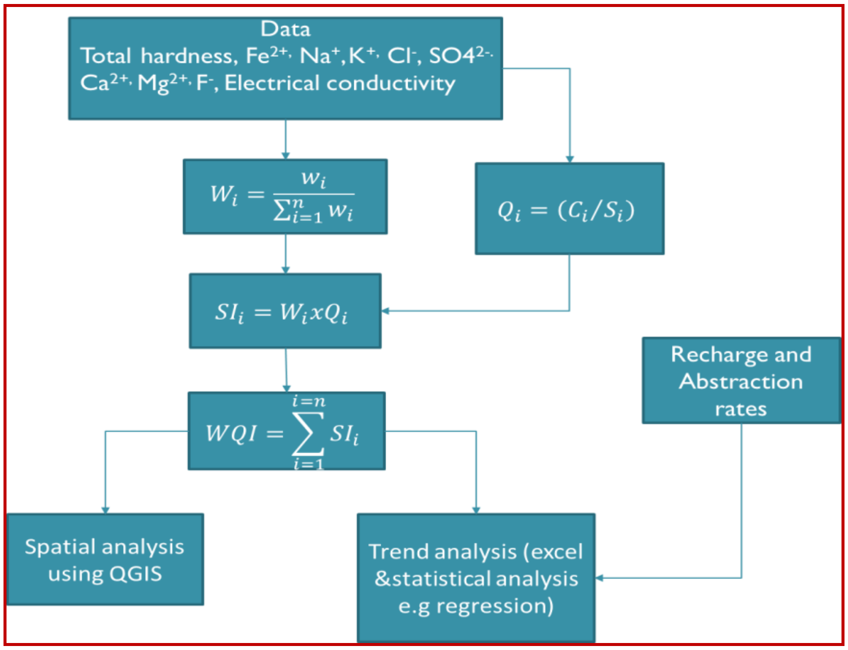

Fig. 2 Computational flowchart for water quality index and recharge and abstraction

a) Water Quality Index Computation

The water quality index (WQI) was calculated using the parameter concentration data obtained from WRA (2013-2019) and that obtained from laboratory analysis using the DRASTIC model, which is a mathematical model that indicates the overall water quality as shown in Fig. 2. It is a method of ranking that provides the composite power of individual water quality parameters on the overall quality of water [2].

The same parameters were chosen for all boreholes based on the hydro-chemical approach based on their level of occurrence and prevalence during borehole commissioning according to WRA data [19] and their indication of the suitability of water for human consumption. The weighting of the parameters was done according to their importance on overall WQ for drinking purposes and their perceived effect and severity on primary human health [26]. A parameter was assigned a weight ranging from 1 showing minimum weight to 5 showing maximum weight as shown in Table 1, where 1 is the lowest value and 5 is the highest. EC was assigned 5 because of its overall indication of water quality; fluoride 4 because of the effect of dental and skeletal fluorosis to humans in high levels and chloride because of weakening of skeletal structure and alkalosis; Calcium, magnesium, and total hardness 3 because of scaling and resistance to detergents; potassium and sodium 2 because of their contribution to maintaining body water balance; iron 1 because of the staining effect and sulfates because of its taste in water.

Table 1. Weighting of chemical parameters

S/No.	Chemical Parameters	WHO Standard (Si)	Weight (wi)
1	Electrical Conductivity(μS/cm)	500	5
2	Magnesium (mg/l)	50	3
3	Calcium (mg/l)	75	3
4	Iron (mg/l)	0.3	1
5	Potassium (mg/l)	50	2
6	Sodium (mg/l)	200	2
7	Sulphate (mg/l)	250	1
8	Total hardness (mg/l)	500	3
9	Flouride (mg/l)	1.5	4
10	Chloride (mg/l)	250	3

Relative weight was calculated using the weighted arithmetic index formula [2].

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (2)$$

Where W_i = Relative weight; w_i= weight of each parameter; n = number of parameters

The quality rating scale (Qi) is calculated by;

$$Q_i = (C_i / S_i)x100 \qquad (3)$$

Where C_i is the concentration of a parameter for each water sample and S_i is its relevant standard according to the World Health Organization (WHO) rule.

The subindex of the ith parameter (SI_i) for each parameter was determined using the equation;

$$SI_i = W_i x Q_i \qquad (4)$$

WQI was given by equation5;

$$WQI = \sum_{i=1}^{i=n} SI_i \qquad (5)$$

The WQI result obtained classified according to the Water quality grading scale by [19] as shown in Table2

Table 2. Water Quality Grading Scale

Ranking	WQI	GRADE
Excellent	<0.2	A
Very good	0.2-0.4	B
Good	0.4-0.6	C
Fairly good	0.6-0.8	D
Suitable	0.8-1.0	E
Unsuitable	>1.0	F

b) Statistical and spatial Analysis

Data and trends were analyzed using excel, while statistical analysis was done using a multiple regression model to establish the relationship between recharge, abstraction, groundwater levels, and water quality index. Spatial analysis was done using QGIS to highlight the spatial variation of different parameters to develop maps of the Water Quality Index.

c) Scenario Analysis

The effect of abstraction and recharge on WQI in the form of the developed model was applied in extreme conditions such as areas of high recharge and low abstraction and areas of low recharge and high abstraction to test and validate the model and check the best and worst scenarios.

III. RESULTS AND DISCUSSIONS

A. WQI, Abstraction and recharge trend

Obtained abstraction data, calculated average recharge, and WQI showed in Table 3 were plotted to show their trends over the year and relationships.

Table 3. Abstraction, Recharge, and WQI in NAS over the years

Year	Recharge (CM/Y)	Abstraction (CM/Y)	WQI
2000	211,602.24	41,186,600.00	0.3219028
2001	623,051.04	41,586,600.00	0.2911604
2002	683,685.60	41,886,600.00	0.3033908
2003	346,483.20	41,586,600.00	0.2861268
2004	862,495.68	42,086,600.00	0.3049508
2005	454,759.20	42,186,600.00	0.3016852
2006	704,722.08	42,586,600.00	0.305866
2007	380,512.80	43,156,600.00	0.29453
2008	246,250.56	43,586,600.00	0.315954
2009	236,351.04	44,886,600.00	0.3228388
2010	606,964.32	45,886,600.00	0.2960276
2011	422,585.76	46,886,600.00	0.340457004
2012	764,737.92	47,586,600.00	0.336937292
2013	603,870.72	48,186,600.00	0.330867156
2014	351,432.96	49,586,600.00	0.33771044
2015	690,491.52	50,886,600.00	0.363431891
2016	458,471.52	51,151,100.00	0.361289491
2017	275,330.40	52,163,200.00	0.390251624
2018	752,363.52	52,963,200.00	0.36317
2019	403,405.44	53,163,200.00	0.36803796
2020	666,980.16	54,963,200.00	0.400577904

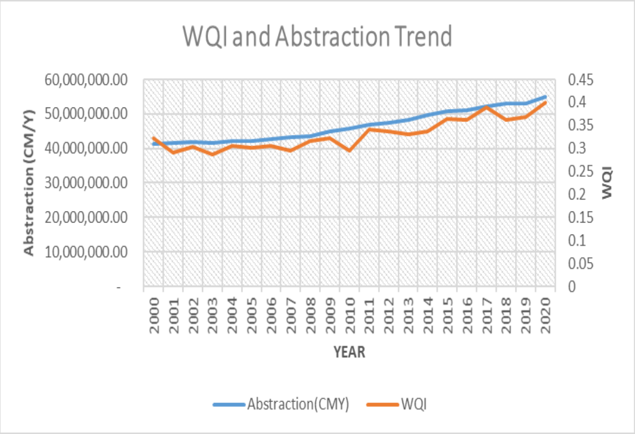

Fig. 3 WQI and Abstraction Trend

There is a significant increasing abstraction and WQI trend, as shown in Fig. 3. This is because of the increasing water demand in the area for various purposes. An increase in abstraction amounts increases WQI lowering the water quality. This implies that the groundwater quality has deteriorated from 2013 to 2020. However, there is a WQI dip in the years 2010 and 2018, which can be associated with the increase in recharge in the year as shown in Fig. 4, thus causing a dilution effect in groundwater hence lowering WQI.

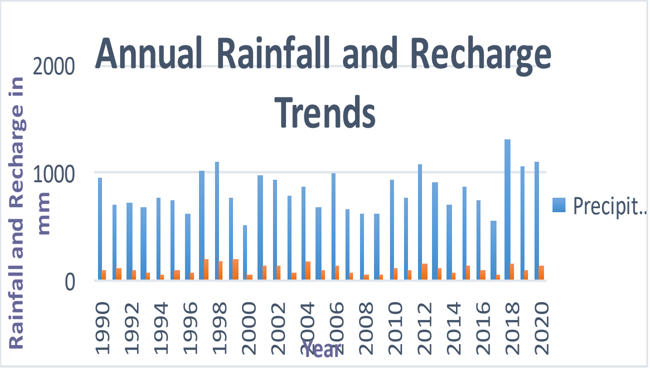

Fig. 4 Annual recharge and rainfall trend

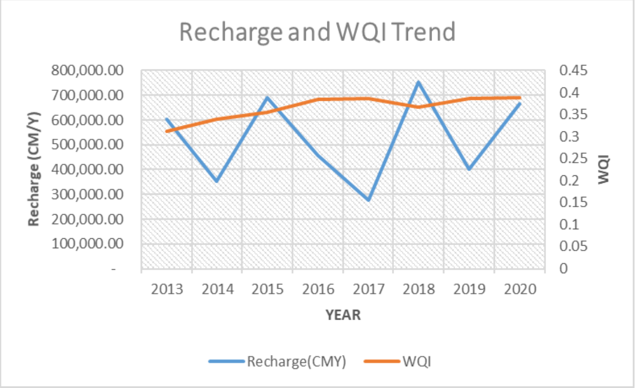

Fig. 5 Recharge and WQI

There is an increase in WQI from 0.33 in 2013 to 0.40 in 2019, as shown in Fig. 5. With the decrease in recharge, the WQI seems to increase as in the case of 2016 and 2017 because of decreased rainfall, meaning an increase in recharge tends to improve the water quality by lowering the water quality index

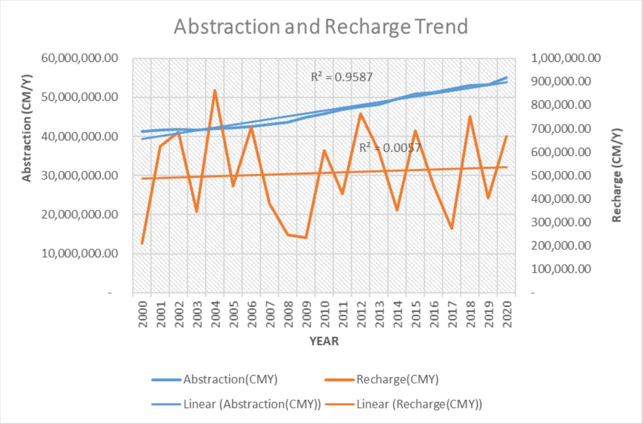

Fig. 6 Abstraction and Recharge trend

Both recharge and abstraction rates showed an increasing trend from 2000 to 2020, as shown in Fig. 6. However, the trend is significant for abstraction as R^2 is 0.9587, which is more than 0.5, while it is not significant for recharge as R^2 is 0.0057. This can be associated with increases in rainfall amounts over the years and a dip in 2017 because of reduced rainfall, as shown in Fig. 4. However, it's not as significant because it's hampered by the increase of urbanization that reduces infiltration.

B. Multiple Regression Model

Recharge, Abstraction, and WQI variables for the years 2013 to 2020 were used to develop a multiple regression model using the analysis tool in excel

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \tag{6}$$

$$WQI = -0.2128 + (1.1763 * 10^{-8} X_1) - (5.6862 * 10^{-8} X_2) \tag{7}$$

Where;

X_1 is Abstraction, and X_2 is recharge

Results showed that Recharge and abstraction have a strong impact on WQI as the R^2 was 0.724. Further, the model showed that WQI is directly proportional to abstraction rate, increasing with an increase in abstraction rate while it is inversely proportional to recharge rates as it decreases with increases in recharge and vice versa, as can be seen in Fig. 3 and 5.

Assuming WQI is maintained at 1 with a recharge rate of 666,980.2m^3/year, the model showed a maximum abstraction of 106,327,112.8m^3/years permissible after maintaining water quality at an acceptable suitable class.

C. Spatial Distribution of Water Quality Index

Water quality results for the 100 boreholes sampled and their calculated WQI as shown in Appendix A were mapped to show the spatial distribution of the water quality index in NAS as shown in Fig. 7.

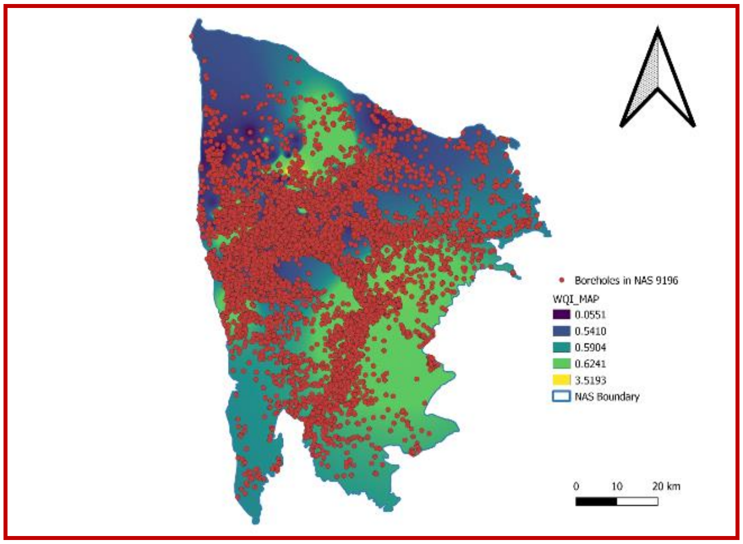

Fig. 7 WQI and Abstraction Boreholes Map of NAS

Results showed that most parts of the study area had water suitable for human consumption because the WQI was below 1. However, small parts of the study area had WQI above 1, e.g. south Eastern parts of Kajiado and Machakos, as shown in Fig. 7. This means that the water was classified as unsuitable for human consumption. This can be associated with relatively high abstraction rates in the area because the area is Arid and Semi-arid (ASAL), as shown in Fig. 6. Most people in these areas depend on groundwater as surface water is limited. The inter-basin water transferred from Tana through Nairobi Water and Sewerage Company rarely reaches those areas.

On the other hand, the area also receives low rainfall, which translates to low recharge rates even if abstraction is relatively low in some areas, as shown in Fig. 8. The Northern part of the study area has low WQI. This is because the of high recharge experienced in the area because of high rainfall amounts, as shown in Fig. 8. The area has sufficient surface water making dependence ground relatively low. The WQI in the central area where Nairobi city fall is ranked as good to fairly good (WQI is 0.4-0.6). Even though the area receives a relatively high rainfall amount, its WQI is influenced by high abstraction rates and reduced recharge due to urbanization that affects land cover.

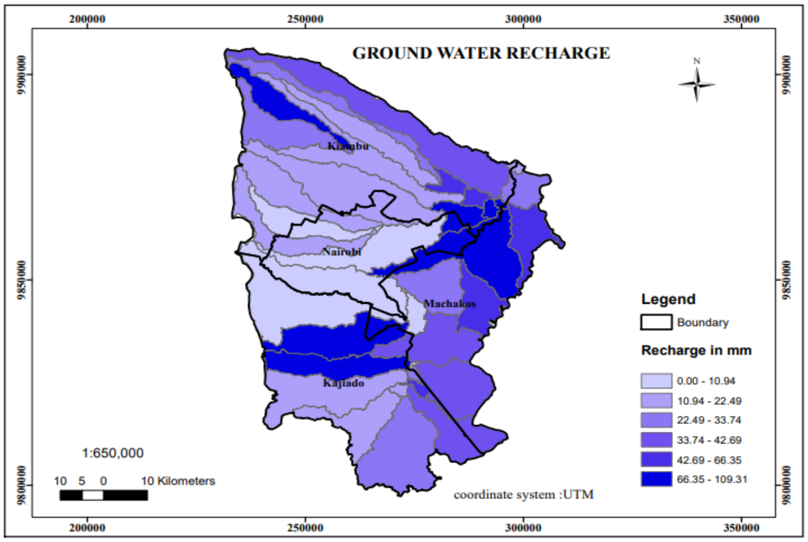

Fig.8 NAS Recharge map

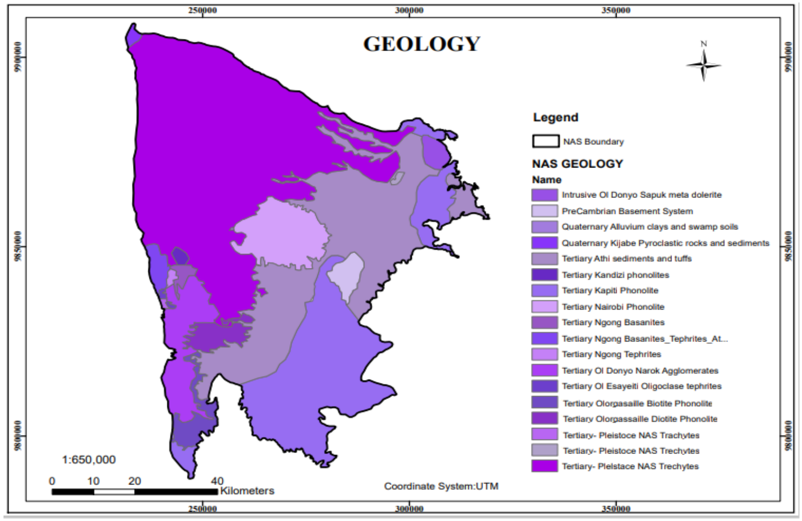

Fig. 9 Map of NAS geology

Comparing the water quality with the geological formation of the area, results showed that areas with Pleistocene trachytes containing calcium, sodium, and potassium, such as the North-Western parts of Ngong hills and Limuru had low WQI, as shown in Fig. 9, which is associated with higher water quality. Areas with phonolites that contain potash and feldspar, such as the Southeastern parts of Kajiado and Machakos, exhibited high WQI because of high concentration of fluoride as a result of groundwater dissolving the mineral elements contained in the geological formation [29] and [21], which make the water unsuitable for human consumption as shown in Fig. 9.

D. Scenario Analysis

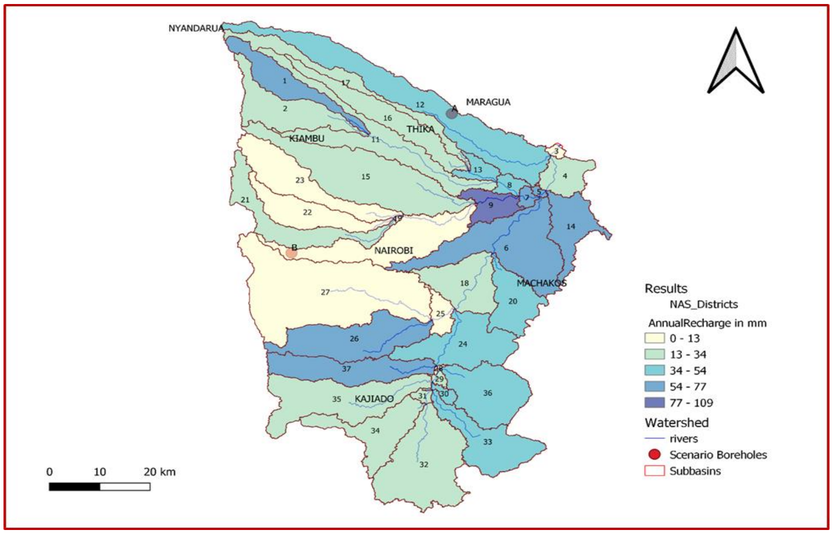

Fig. 10 Scenario analysis map

Considering a borehole located in a high abstraction and low recharge area in Nairobi (Borehole B) another one in higher recharge and low abstraction area (Borehole A) as shown in Fig. 10, the calculated WQI was found to be 0.6 and 0.2, respectively. The WQI of samples from an area with high recharge and low abstraction rate is low because the dilution effect is higher, making the concentrations of the minerals low making the water more suitable for human consumption. Moreover, water from the borehole located in a low recharge and high abstraction area showed a higher WQI since the dilution factor was low, leading to the high concentration of minerals making the water unsuitable for human consumption. This clearly explains the effect of recharge and abstraction on WQI and agrees well with the developed multiple regression model.

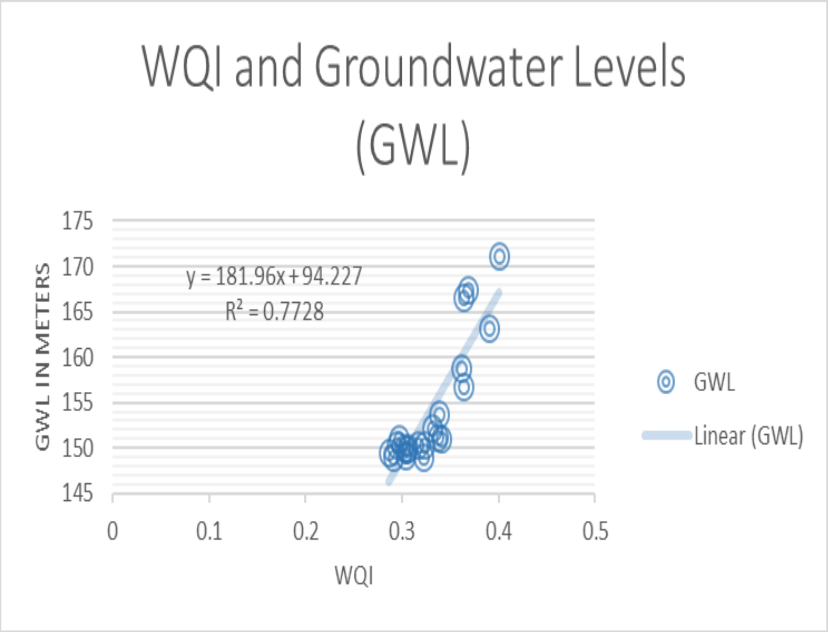

Fig. 11 Graph of Groundwater levels and WQI

WQI showed a strong correlation with groundwater levels with an R^2 of 0.77, as shown in Fig. 11. This means that as groundwater levels increased, the WQI increased, implying that water quality deteriorated. The increase in groundwater levels is caused by reduced recharge. An increased abstraction rate makes the water more concentrated because of the low dilution of the minerals present in groundwater resulting in increased WQI and vice versa.

IV. CONCLUSION AND RECOMMENDATIONS

It was concluded that abstraction and recharge rates affect water quality in NAS as water quality improved (WQI decreased) with a decrease in abstraction and an increase in recharge and deteriorated (WQI increased) with an increase in abstraction and reduced recharge, making the water unsuitable for human consumption. Therefore, it was recommended that abstraction be regulated in line with recharge rates and recharge be improved to maintain high water quality suitable for human consumption. These findings are important to water resources managers and regulators as they can act as a management tool to control groundwater abstraction according to the available recharge and find alternatives for enhancing recharge.

APPENDIX A

Results of groundwater quality analysis

BH-NO.	East (X)	North (Y)	COND	FE	CA	MG	NA	K	THARD	CL	F	SO4	WQI
C-1017	266322.2	9865504	550	0.4	4	0	143	15	10	8	1.1	20	0.3345
C-10198	255189.3	9865495	220	0.1	26	9.3	25	4.7	104	9	0.4	2.3	0.2100
C-10201	249635.4	9850890	380	0.2	5	0.4	73	9	14	25	1.8	20	0.2599
C-10201	249635.4	9850890	280	0.3	3.2	0.1	91	13	8	27	3.5	10	0.2913
C-10202	233803.5	9875544	225	0.1	5.6	1.9	54	13	22	23	0.5	8.5	0.1900
C-10202	233803.5	9875544	180	0.1	8.8	0.98	42	15	26	26	0.8	47	0.1977
C-10817	279451.5	9874915	410	0.4	25	4.8	53	7.9	82	7	1.7	4.2	0.2864
C-10820	250624.4	9865824	300	0.4	12	5.4	39	15	52	28	1	8.3	0.2392
C-1202	249618.1	9871022	550	0.7	14	4.4	90	13	54	55	0.9	9.6	0.3440
C-1238	247718.2	9880201	344	0.7	2.9	2.4	23	14	17	32	0.68	9.7	0.2909
C-1244	249612.4	9878322	320	0.5	2	0	38	2	5	8	10.2	8	0.4129
C-1340	262530.1	9874682	700	0.4	75	42	100	45	358	10	0.8	10	0.6662
C-1340	262530.1	9874682	950	0.5	75	30	90	21	322	7.8	1.4	1	0.6618
C-1401	266316.7	9872804	325	0.8	9.3	36	92	18.2	38	22	1.4	4.3	0.4908
C-1424	262528.7	9876562	960	1.0	77	31	100	16	318	9.8	1.3	1.1	0.7397
C-1439	249613.8	9876553	60	0.1	3.2	1.5	7.4	3.4	14	4	0.8	2	0.0692
C-1448	258857.6	9872799	150	22	10	1	9	3	28	10	0	0	2.6922
C-1468	240275	9859952	580	0	28	8	70	13	114	41	0.2	61	0.3316
C-169	166021.4	10000000	430	0.41	25	30	61	11	64	275	0.13	13	0.4585
C-2145	264429.7	9865503	848	0.1	8	0.1	78	19	20	22	6	6.2	0.4528
C-2334	271885.7	9869158	220	1.1	7	0.2	75	14	20	45	0.2	7.8	0.2951
C-2358	232919.7	9867247	260	0.1	1	0.4	140	13	12	22	1.4	10.3	0.2533
C-2378	268092.7	9880216	226	4.8	5.9	2.1	98	18	24	0.24	1.6	1.2	0.7448
C-2602	249619.6	9869141	279	1	7.2	2.9	40	12	30	10	1.5	10	0.2357
C-2675	256960.8	9878328	670	0.1	41	32	94	24	238	22	1.3	2	0.5051
C-2717	231030	9863594	375	0.1	10.4	3.6	170	13	52	17	2.2	3.3	0.3440
C-2754	279222.9	9883873	240	1.3	4	9.6	25.5	11	50	30	0.12	15.8	0.3256
C-2793	258861.9	9867268	310	0.5	2	1	35	3	10	8	9.4	4	0.3938
C-2902	255184.9	9871026	210	0.3	3.3	1.6	69	11	17	20	0.13	10.1	0.1998
C-2980	268099.2	9871036	1160	0.6	61	21	160	31	238	10	0.8	13	0.7066
C-2980	268099.2	9871036	1130	0.4	36	14	226	36	150	9	1.1	8	0.7066
C-2999	240275	9859952	365	0.3	8.2	4.8	45	14	41	32	0.24	22	0.2267
C3074	236600.7	9859948	370	0.4	16	4	48	13	58	38	0.2	24	0.2652
C-3074	236600.7	9859948	370	0.4	16	4	48	13	58	38	0.2	24	0.2652
C-3091	253292.2	9871025	148	0.2	4	1.5	17	5	16	13	0.5	2.5	0.1101
C-3091	253292.2	9871025	148	0.2	4	1.5	17	5	16	13	0.5	2.5	0.1101
C-3100	256973.7	9861736	280	0.05	1.6	1	55	5.8	16	3	6	25	0.2714
C-3113	249611	9880203	1270	0.01	28	13	274	1	122	2	3.7	27	0.6710
C3141	256976.8	9858086	990	0.2	44	16	144	26	182	12	0.9	15	0.5578
C-3141	256976.8	9858086	990	0.2	44	16	144	26	182	12	0.9	15	0.5578
C-3141	256976.8	9858086	880	0.4	44	14	169	26	170	10	1.1	4	0.5578
C-3383	236586.4	9876542	170	0.3	9.6	4.9	54	5.4	44	8	0.3	2	0.2513
C-3418	236595.7	9865480	290	0.5	7.1	2.7	55	5.7	30	11	0.4	4	0.2979
C-3448	242166.2	9861723	390	23	8.6	3.8	225.6	41	38	99	0.3	123	3.0001
C-3642	238491.9	9861720	1420	1.1	80	19	73.5	39	276	26	0.8	36	0.8220
C3771	249619.6	9869141	410	6.4	9	3	50	12	36	30	0.9	30	0.9832
C-3771	249619.6	9869141	410	6.4	9	3	50	12	36	30	0.9	30	0.9832
C-3818	266319.4	9869154	1280	0.08	74	28	220	35	300	22	1.2	6.6	0.7871
C-3818	266319.4	9869154	1280	0.08	74	28	220	35	300	22	1.2	6.6	0.7871
C-3897	245823.9	9882081	66	0.1	3	1	5	2	12	4	0.2	5	0.0512
C-3898	264416.3	9883864	1450	0.1	39	64	83	11	800	98	0.44	147	0.9301
C-3911	247721	9876551	175	0.4	19	1	14	4	52	7	0.2	9	0.1543
C-3919	249618.1	9871022	153	0.2	14	1	16	8	42	4	0.6	5	0.1296
C-3919	249618.1	9871022	153	0.2	14	1	16	8	42	4	0.6	4	0.1296
C-3961	255180.7	9876557	233	0.2	8	6	26.5	11.5	46	17	0.9	9.5	0.1838
C-3972	275555.3	9874691	170	5	5.8	1.4	19	1.3	28	18	0.2	27	0.6907
C-3972	275555.3	9874691	540	0.6	15	2	72	8	48	40	4	20	0.6907
C-3982	279227.7	9876574	275	4	2.4	0.2	58	0.5	8	33	3	4	0.3815
C-3998	234690.5	9880191	165	1.6	5	3	25	6	22	8	0.6	4	0.2938
C-4003	249616.7	9872792	152	7	8	3	33	3	34	31	5	5	1.0637
C-4017	260755.9	9865500	550	0.4	4	0	143	15	10	8	1.1	20	0.3345
C-4019	279221.7	9885753	310	0.2	14	4	43	9	50	35	0.1	7	0.2053
C-4029	258866.3	9861738	500	0.1	16	0.5	76	7	42	27	0.5	5	0.2492
C-4037	245832.5	9871019	260	0.1	7	0.5	38	8	20	28	0.2	5	0.1481
C-4038	238477.9	9878314	104	0	6	1	7	4	22	9	0	0	0.0556
C-4046	238493.5	9859950	1280	0.1	178	36	11	9	594	340	3.2	6	1.5170
C-4117	256963.5	9874678	220	20	7	2	27	8	26	34	1.2	4	2.5341
C-4126	260754.5	9867270	390	0.4	5	2	83	12	20	12	9.8	6.5	0.4685
C-4139	258864.8	9863618	370	3	3.2	7	83	6.5	88	11	19	9	0.9910
C-4224	264428.3	9867273	656	0.9	7	3.4	28	14	88	142	0.45	7.1	0.4753
C-4249	266319.4	9869154	650	0.79	5	3.1	25	12	72	19	0.52	6.3	0.3844
C-4286	277440.5	9885752	245	0.16	3	2.3	75	8.5	56	10.7	0.93	4.2	0.2316
C-4409	268100.6	9869156	700	0.27	4	2.9	23	14	156	14.5	1.25	5.8	0.3761
C93	166021.4	10000000	318	0.16	24.8	2.53	43.8	8.2	74	61	0.45	1.2	0.3076
C-93	166021.4	10000000	320	0.1	20	5.3	38	7	72	55	0.3	5.7	0.2824
C-93	166021.4	10000000	190	0.6	2.3	1.9	18	6.2	39	32	1.7	3.5	0.2153
C-93	166021.4	10000000	400	0	17.2	5.5	26	6.2	66	49	0.2	7	0.2093
C-93	166021.4	10000000	220	0.83	6.2	6.1	25	10	634	51	0.32	5	0.4016
C-93	166021.4	10000000	210	0.1	6.2	2.3	24	9.5	34	38	0.45	2	0.1488
C-93	166021.4	10000000	240	0.91	3.1	6	75	5.9	102	47	0.17	8.1	0.7827
C-93	166021.4	10000000	440	0.2	15.8	7.9	20.5	8	72	30	0.21	3.4	0.2174
P-124	166021.4	10000000	664	1	3.2	3.4	36	13	22	24	2	15	0.3937
C-89	166021.4	10000000	270	0.1	40	6.3	19.5	10	125	35	0.32	3.9	0.2759
C-10489	243390.8	9861835	360	0.6	16	6.8	38	11	68	48	0.7	3.8	0.7051
C-1091	255183.5	9872796	202	38	1.5	0.8	24	18	30	16	0.4	0.3	4.6318
C-11040	270000.9	9859203	560	0.07	5.6	3.84	109.1	10.35	30	25	4	12	0.3630
C-11045	242397.1	9852653	360	1.23	25	3	43.7	13.8	74	16	0.8	23	0.3717
C-11087	237478.1	9875437	230	0.01	8	4.8	27	11	40	20	0.4	5	0.1444
C-1150	249625.8	9861730	380	0	26	1	38	17	70	38	0.3	2	0.2227
C-1208	256959.4	9880208	400	0	8	3	78	5	32	28	3.2	20	0.2773
C-1259	242408.3	9841148	850	2	80	32	75	1	334	99	0.9	21	0.8507
C-1259	242408.3	9841148	800	0	86	12	35	14	365	60	0.8	17	0.5357
C-1317	256963.5	9874678	350	4.8	3.2	0	76	5.6	8	13	8.8	0.7	0.9340
C-1629	279221.7	9885753	330	0.2	14	1	48	10	42	36	1.1	5	0.2283
C-1810	256960.8	9878328	260	0.52	24	4.1	35.4	6	44	29.6	0.01	6	0.2300
C1939	251395.2	9876554	77.2	1	3.2	1.94	11	3.6	16	7	1.25	0.1	0.3160
C-20	166021.4	10000000	465	0.1	80	13	34	12.5	88	55	0.7	15	0.5293
C-234	271911.6	9837858	1730	2	3	9	358	5	30	245	0.7	179	0.9723
C-2343	260757.4	9863620	420	0.6	1	1	96	3	6	16	1	4	0.2762
C-335	281143.8	9845166	2000	0.3	176	0	216	19	440	400	3.1	25	1.3581

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